A Retrieval Approach for Human/Robotic Musical Performance

Ajay Kapur
University of Victoria
Victoria, BC, Canada
ajay@@uvic.ca

Eric Singer
LEMUR
Brooklyn, NY, USA
e@ericsinger.com

Abstract

This paper describes a MIR-based system for live musical performance between a human and a robot. This project involves combining human computer interface with musical robotics using query/retrieval architecture to create musical rhythmic phrases towards improvisation.

Keywords: MIR Live Performance System, Musical Robotics, Interface-based MIR, Electronic Sitar, KiOm.

1. Introduction

The role of music information retrieval (MIR) in developing systems for live performance on stage is an emerging area of research. The ability to use algorithms developed throughout the years in real-time as computers become faster and faster has allowed for ideas which seemed like dreams to become a reality. Our dream has been to create a system for live performance between a human musician and a musical robot using MIR techniques.

A number of engineers and artist have made headway in this area. The art of building musical robots has been explored and developed by musicians and scientists such as [1-6]. A comprehensive review of the history of musical robots is described in [7].

The area of machine musicianship is another part of the puzzle. Robert Rowe describes a computer system which can analyze, perform and compose music based on traditional music theory [8]. Other systems which have influenced the community in this dominion are Dannenberg's score following [9], George Lewis's Voyager [10], and Pachet's Continuator [11].

There are few systems that have closed the loop to create a real live human/robot performance system. Audiences who experienced Mari Kimura's recital with the LEMUR GuitarBot [12] can testify to its effectiveness. Gil Weinberg demonstrates Haile, a robotic drum player which taps along with a human [13].

This paper will describe our approach to creating a human/robotic performance system. Section 2 will describe the tools which have been created, including custom built human computer interfaces and musical robots. Section 3 will describe the software framework and basic MIR based retrieval system. Section 4 will present discussion on current progress and future goals.

2. Tools

As shown in Figure 1, in order to carry out this research, one must have access to a custom built musical controller, a functional musical robot, and programmable computer music software. This section describes the tools used in the early stages of experimentation. Keeping with North Indian tradition, in this project the human will be performing a sitar, a 19-stringed gourd-like instrument, and the machine will be providing rhythmic accompaniment. In the early stages of design, algorithms are tested using audio samples played through speakers, as well as experimentation using simple percussion robots.

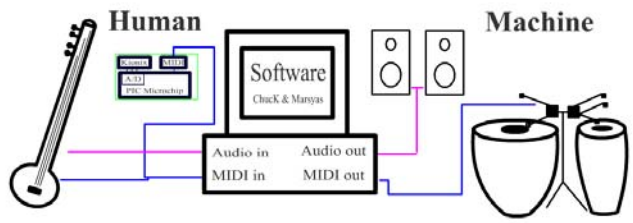

Figure 1 - Human/Machine Music Performance Diagram.

2.1 Machine Perception

In order for a robot to interact with a human it must be able to sense what the human is doing. In a musical context, the machine can perceive human communication in three general categories. The first is directly through a microphone, amplifying the audio signal of the human's musical instrument. The second is through sensors on the human's musical instrument. The third is through sensors placed on the human's body, deducing gestural movements during performance using camera arrays or other systems for sensing, analogous to the machine's eyes.

Sound. The sound of the sitar is easily obtained via a contact microphone/pickup clipped on to the bridge of the instrument.

Sensors on Musical Instrument. The ESitar [14] is a hyperinstrument which obtains musician's gestural data of traditional performance techniques. Fret detection and thumb pressure are the two key pieces of information used to capture musical meaning and method.

Sensors on the Human Body. The KiOms [15] are controllers which can be attached to the human body. They convert 3-axis accelerometer readings to MIDI for use with any audio software, or synthesizer. Twelve KiOms were built, so the performer can put them on their head, hands, arms, and feet. In our initial experiments a KiOm was placed on the head of the performer deducing x-, and y- axis of tilt.

2.2 Musical DeviBot

ModBots [16] are modular robots that can be attached virtually to any fixture. These robotic devices listen for MIDI signals to control strength of stroke and can be affixed to simple folk Indian drums, a drum set, or any percussion instrument from around the world. In our initial experiments we combined 3 ModBots together to create "DeviBot", which strike low and high frame drums and a Tibetan gong, beginning our first Indian accompaniment drum robot.

3. MIR Framework

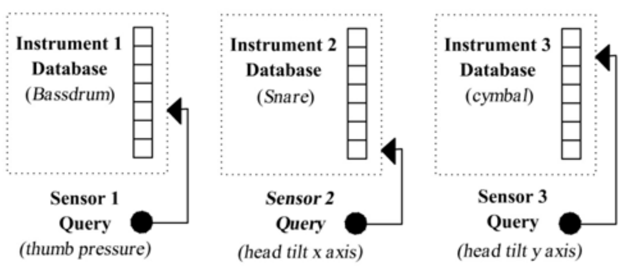

Figure 2 - MIR Framework for Human/Robot performance.

Our initial framework for this project was written in ChucK [17], a concurrent, strongly-timed audio programming language that can be programmed on-the-fly. The goal of this system is to generate a variation of rhythmic accompaniment which evolves over time based on human performance. To achieve this, our main idea is to set up a database of musical rhythmic phrases specific to each individual instrument. Queries for the database are generated by sensor data captured from the human performer. The databases are time and tempo locked to each other to allow for multiple permutations and combinations of rhythm. Figure 2 shows an example of how the system can be mapped. In this case, thumb pressure from the ESitar will query which bass drum pattern the robot will mechanically play on the low frame drum.

4. Discussion

One issue to address is how the queries are generated. There are many algorithms which can be explored; however the main philosophical question is whether the human should have full control of the machine's performance. Another observation was discerning the difference between robotic accompaniment and sample-based accompaniment. There are so many audio effect algorithms developed which can be controlled by sensor data from the human performer to create a vast amount of variety in machine performance. With our robot up to date, there is only one dimension of expression which can be controlled. Thus more degrees of mechanical freedom for expression must be designed.

5. Acknowledgments

Thanks to Manjinder Benning for his code to auto detect tempo in ChucK. Thanks to Perry Cook and Ge Wang for designing the ChucK language and their constant support. Special thanks to Trimpin for his inspiration. Thanks to George Tzanetakis for inspiration and guidance.

References

[1] Trimpin, SoundSculptures: Five Examples. 2000, Munich MGM MediaGruppe Munchen.
[2] Takanishi, A. and M. Maeda. Development of Anthropomorphic Flutist Robot WF-3RIV. in ICMC. 1998. Michigan, USA.
[3] Jorda, S. Afasia: the Ultimate Homeric One-Man-Multimedia-Band. in NIME. 2002. Dublin, Ireland.
[4] MacMurtie, C., Amorphic Robot Works.
[5] Baginsky, N.A., The Three Sirens: A Self Learning Robotic Rock Band.
[6] Raes, G.W., Automations by Godfried-Willem Raes.
[7] Kapur, A. A History of Robotic Musical Instruments. in ICMC. 2005. Barcelona, Spain.
[8] Rowe, R., Machine Musicianship. 2004, Cambridge, MA: MIT Press.
[9] Dannenberg, R.B. An On-line Algorithm for Real-Time Accompaniment. in ICMC. 1984. Paris, France.
[10] Lewis, G., Too Many Notes: Computers, Complexity and Culture in Voyager. Leonardo Music Journal, 2000. **10**: p. 33-39.
[11] Pachet, F. The Continuator: Musical interaction with Style in ICMC. 2002. Goteborg, Sweden.
[12] Singer, E., K. Larke, and D. Bianciardi. LEMUR GuitarBot: MIDI Robotic String Instrument. in NIME. 2003. Montreal, Canada.
[13] Weinberg, G., S. Driscoll, and M. Parry. Haile - A Preceptual Robotic Percussionist. in ICMC. 2005. Barcelona, Spain.
[14] Kapur, A., et al. The Electronic Sitar Controller. in NIME. 2004. Hamamatsu, Japan.
[15] Kapur, A., et al. Wearable Sensors for Real-Time Musical Signal Processing. in IEEE Pacific Rim. 2005. Victoria, Canada.
[16] Singer, E., et al. LEMUR's Musical Robots. in NIME. 2004. Hamamatsu, Japan.
[17] Wang, G. and P.R. Cook. ChucK: A Concurrent, On-the-fly Audio Programming Language. in ICMC. 2003. Singapore.